What's Wrong with UK Spares Provisioning?

Recent strategic events have highlighted the need to restore the 'hollowing out' of Armed Forces by improving Resilience and restoring stockpiles despite their previous financial anathema. But we must not just engage in a spending spree as we must spend tax-payers money wisely.   Resilience cannot be achieved just by buying more spares however attractive it may be for suppliers. As a recent paper by the Supply Chain Council stated *"Stockpiling is Fragility Disguised as Resilience".* UK CLEP also commented in a recent White Paper that improved Resilience will only be achieved through a comprehensive balanced approach to all aspects of Support - spares, trained people, technical documentation, support equipment, facilities, information etc.

Procuring additional spares is vital but UK practices over the last 20 years have not been efficient nor effective. The evidence is stark. The National Audit Office first raised the alarm in 1991. Subsequent House of Commons Public Accounts and Defence Select Committee reports often repeated the call for improvement. Anecdotally, Wessex spares were valued in the mid-90's at more than £25M; these were largely high-cost, high-reliability items which had sat on the shelf for many years and, even if they had been needed, would have needed significant modification. In 1992, MOD ordered 6 new Sea King Mk3A aircraft without main rotor gearboxes to use up excess spares.   Between 2009-11, "MOD purchased 38% more raw materials and consumables than it used spending £1.5Bn more than necessary". In 2013, the PAC warned that MOD was "wasting significant amounts of public money buying equipment and supplies that it doesn't need" with £3.4Bn surplus of unnecessary stock awaiting disposal. By 2023-24, MOD held over 740 million items valued at £10.8Bn but there was "an extremely limited reserve - effectively a thin stockpile of spares and consumables". Over-ordering, near-constant surpluses, systemic inventory mismanagement of shelf-life, weak data, poor oversight systems and slow bureaucratic processes have been persistent themes.

Provisioning Principles

To appreciate what's wrong with UK spares provisioning practices, we need to understand the basic principles of provisioning. Provisioning is the process to identify the stocks to achieve the required operational availability of systems for an affordable cost taking into account the time taken for replenishment by repair or new buys.

Spares provisioning comprises both Initial Provisioning (IP) and Re-Provisioning (RP).

- IP must buy enough repairables and consumables to prime the pipeline with sufficient items until RP processes take effect once in-service experience generates reasonable failure data. IP defines the spares scales for the initial in-service period, typically 2 years, although many items will be used throughout the system life. Trustworthy evidence of demand rates is often unavailable so IP uses the best available predictions of failure modes. Incorrect initial estimates will lead to shortages or excesses that must be resolved even without inevitable changes to reliability rates, prices and user demand. Inventory must be actively managed through-life to sustain, improve and mitigate any deterioration in spares performance.

- Stock replenishment is the key principle in RP. The number of spares consumed in a period is caused by usage of the system and item reliability. In due course, RP uses historic consumption trends as the best indication of future need to refine initial spares estimates to reflect more accurately the future pattern of system failure and spares demand. RP should also reflect changes to the operating pattern, support arrangements, and modified or upgraded configurations. Spares must be reordered sufficiently early to replenish the stock before it runs out given procurement lead times for economic order quantities. As demand rates will vary randomly, safety stocks are prudent to maintain minimum stock levels.

There are 3 typical approaches to calculate spares requirements.

- Engineering Judgement based on experience. This is often inaccurate leading to shortfalls or expensive excess stock holdings.

- Single-Item Modelling assesses each item in isolation to determine how many are needed. It ignores cost which is not a factor in determining the number required. Fill Rates are used to describe the confidence of having a specific part available when required. Typically, each item must achieve the required confidence level which implies that many are over-stocked. For example, if 1 spare provides 60% item availability but 2 spares provide 95% against a target of only 80% availability, 2 spares are procured. This approach is described colloquially as **"Happy Shelves".**

- Availability-based modelling assesses all items simultaneously to identify and select those which provide the greatest cost-weighted contribution to system operational availability for the least cost. Marginal Analysis Techniques use: detailed system equipment breakdown structures; the reliability of each part in each location in the structure; the operational significance of each part in the structure; complex environments where spares are required at multiple locations with partial or full repairs at various levels; and, most importantly, costs which become a discriminant. This approach is described colloquially as **"Happy Systems".**

Over many years, Availability-based modelling has been shown to be 25-33% cheaper than Single-Item modelling and about 50% of Engineering Judgement. This has been substantiated by MOD's own analysis illustrated below and bears out Craig Sherbrooke's original conclusions in his book Optimal Inventory Modelling of Systems.
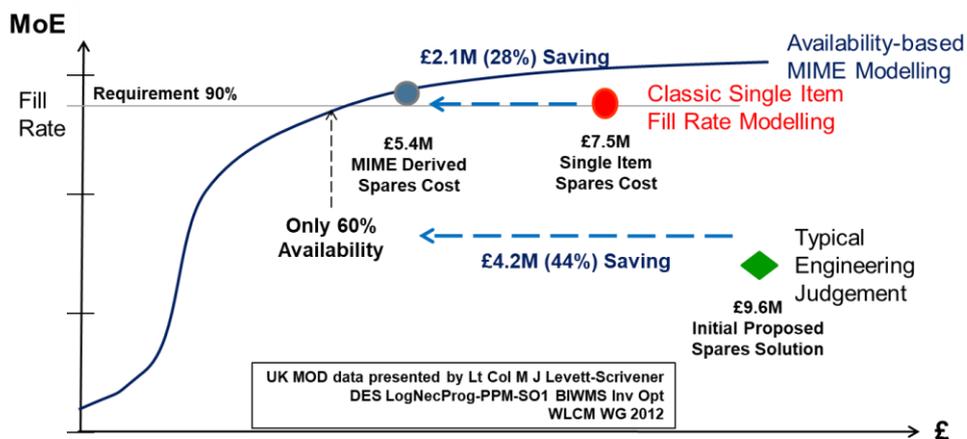
Low-value consumables are an exception. Missing consumables can make a system unavailable but the extra effort to collect data and run comprehensive models outweighs the potential savings. It is usually cheaper and simple to adopt Kanban stock management to provide consumables immediately available wherever and whenever required even if that means over-stocking.

RP – Regular or Automated?

Once initial stock levels are established, they are usually maintained automatically by algorithms within inventory management and ordering systems. MOD's automated RP systems have always used Single item methods to respond to item shortfalls. **But by previous logic, this progressively erodes all the initial IP benefits leading progressively to 25-33% excess stock that is largely unseen.**

Given the potential waste, Availability-based modelling must be used for regular RP. Maintenance policy reviews should be conducted regularly (at least before each contract re-negotiation) and immediately followed by comprehensive review of in-service stock holdings using Availability-based modelling. Unfortunately, this coherent practice is not universal leading to growth in unnecessary stock holdings. Industry will privately welcome the increased order flow and will not complain about the malpractice.

In the past, the Support effectiveness of every weapon system was regularly reviewed to update maintenance policies to reflect changes to usage and experience. Servicing periodicities, component lives and maintenance policies were revisited and subject to reliability-centered maintenance and level of repair analysis. Using refreshed data, RP was conducted using Availability-based not Single Item

modelling to ensure that cost advantages were not lost. As historic logistics IS were less capable, data collection, cleansing and analysis were heavily manual meaning that a 5-year review cycle was the best achievable by the specialist engineering and logistic personnel.

More recently and despite improved IS power, Support Managers do not have the capacity (or mandate) to conduct this activity and the specialist skills have been lost. Automated Single Item RP continues to erode, unseen, the 25-33% cost benefits that were achieved during Availability-based IP.

The ideal approach is continuous, Availability-based RP using an autonomic system to reassesses all items simultaneously. This can be achieved by feeding actual stock holdings, probably at weekly intervals, into the original provisioning models to revise automatically the optimum stock and identify where there are shortfalls. Shortages do not imply immediate procurement in non-economic order quantities as gaps can often be filled by alternative remedies such as use of alternatives, trans-shipping stock, exchange, loans, expediting repair and engineering action. Current software tools have this capability but the linkages to inventory systems have not always been made or used.

Dynamic Repair Management

The same tools can prioritize possible remedial actions by cost and the urgency to make decisions. In his seminal textbook, Craig Sherbrooke projected that, for optimally provisioned systems, **11% more system operational availability would be achieved by managing the order in which repairs were conducted without any more expenditure on spares**. For sub-optimal scales, the benefit can be even greater with up to 20+% improvement in A_o. As a useful by-product, opportunities for 'repair holidays' are automatically identified for items in surplus creating significant cost savings.

Dynamic repair management adjusts specific repair priorities based on the global situation without manual intervention; it is true autonomic management of repair capacity and workload to deliver enhanced system availability. Focusing on system availability to drive the repair facility work plan delivers *'Happy Systems'* rather than *'Happy Shelves'*. These tools also exist but are rarely used.

Conclusions

The standard principles of spares provisioning using Availability-based modelling have been proven to reduce the cost of IP by 25-33% over Single Item modelling. **But the initial benefits of Availability-based IP are progressively eroded by inappropriate use of Single Item modelling for automated RP leading to costly excess stock.**

This weakness used to be mitigated by regular 5-yearly maintenance policy reviews and reprovisioning by specialists using availability-based modelling but the practice and skills have been lost. Through-life Support Managers no longer have the time or expertise to do other than rely upon the inappropriate Single Item RP algorithms.

Buying more spares on the pretext of increasing Resilience will exacerbate this problem and create even more waste. The solution is for SQEP to use existing software tools to focus available budget on what is required from a system-level provisioning perspective. And then, by feeding the tools with current inventory status, automate the process to indicate priorities for dynamic decision making. Range Managers dealing with thousands of line items would greatly welcome such guidance for attention.

Adding Dynamic Repair Management will create an autonomic repair and provisioning system that will be far more effective than the current simplistic but ineffective and inefficient Single-Item methods.

The solution to this problem is simple, cheap, quickly achievable and already exists. It's the lack of process knowledge and SQEP that are missing.